(12) UK Patent Application (19) GB (11) 2 159 561 A

(43) Application published 4 Dec 1985

(21) Application No 8512115

(22) Date of filing 14 May 1985

(30) Priority data
(31) 841937 (32) 15 May 1984 (33) NO

(51) INT CL⁴
E02D 5/60 17/00 E04C 3/30

(52) Domestic classification
E1H CE

(56) Documents cited
GB A 2028405 GB 1494072 US 4306821
GB 1546710

(58) Field of search
E1H
E1D
F2P

(71) Applicant
Viking-Mjondalen A/S (Norway),
3050 Mjondalen, Norway

(72) Inventors
Eric Robert Christiansen
Oystein Hilden
Harold Ruud

(74) Agent and/or Address for Service
A A Thornton & Co, 303–306
Northumberland House,
High Holborn, London WC1V 7LE

(54) Method for applying a protective coating to an elongate structural element of steel, e.g. a riser on an offshore oil rig

(57) The element (31) is sandblasted and possibly coated with a preliminary protective coating by arm (34–36) whereafter a ring (47) is fitted around an upper accessible, region of the element and then moved and secured to a lower accessible region. A first rubber or plastic sheath section (45g) is then placed around the element and its ends joined to encirle the element at a small spacing therefrom. It is then displaced downwardly and a new section (45f) wrapped around the element and joined to the first section. This is repeated until the required length of sheath is reached whereat the sheath is moved into contact with and secured to the ring (47). A filler (e.g. polyurethane foam, a rubber or epoxy compound) is then filled into the space, and the space sealed.

For partly submerged structures, a cofferdam chamber (37) may be provided. The ring (47) may be of rubber and may have as an integral part thereof a heater element to allow curing of the rubber onto the element or sheath.

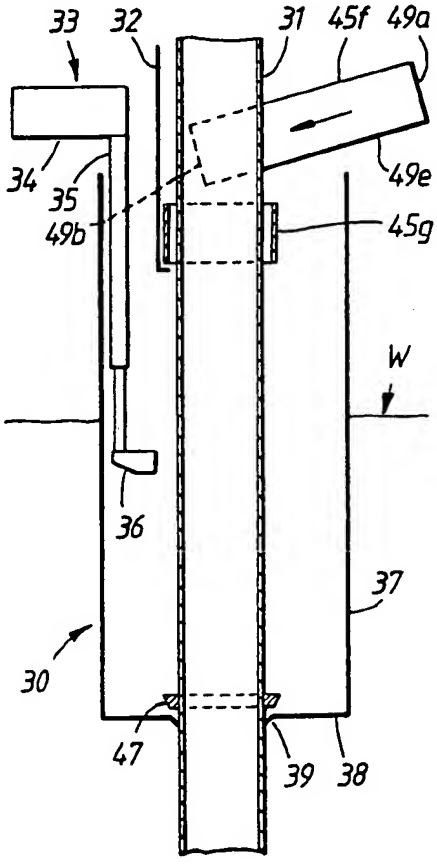

FIG. 3.

GB 2 159 561 A

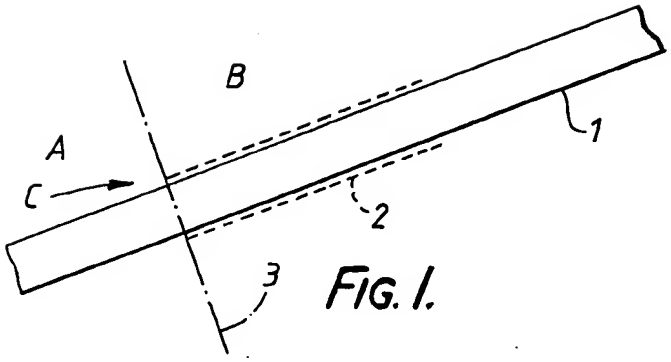

FIG. 1.

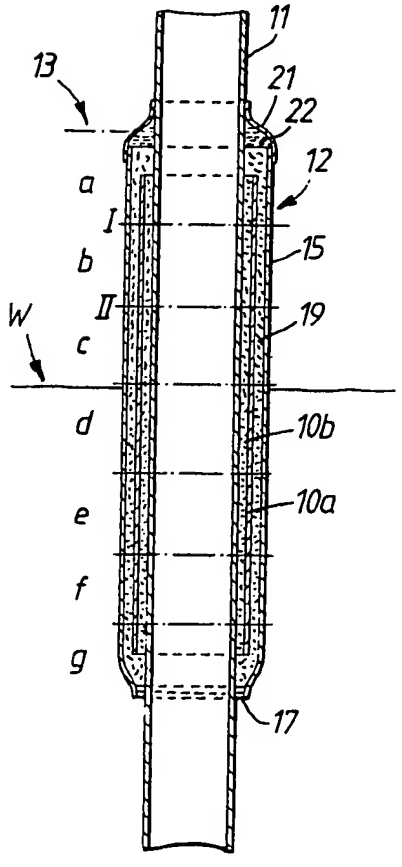

FIG. 2.

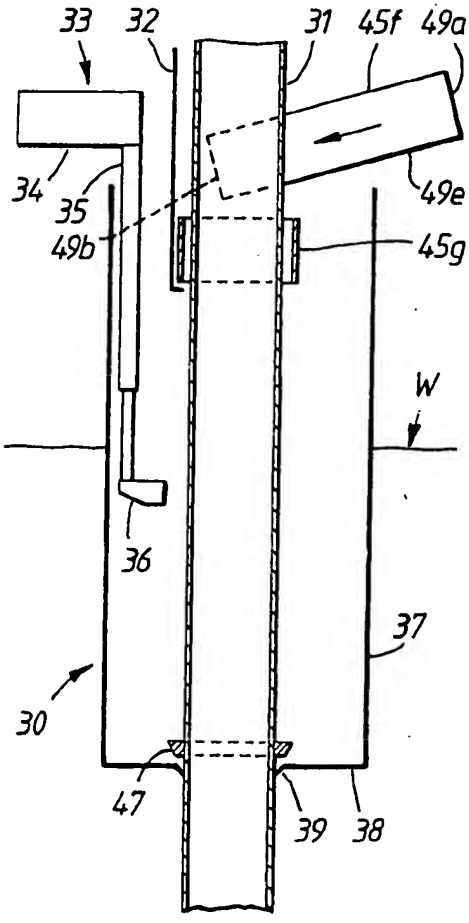

FIG. 3.

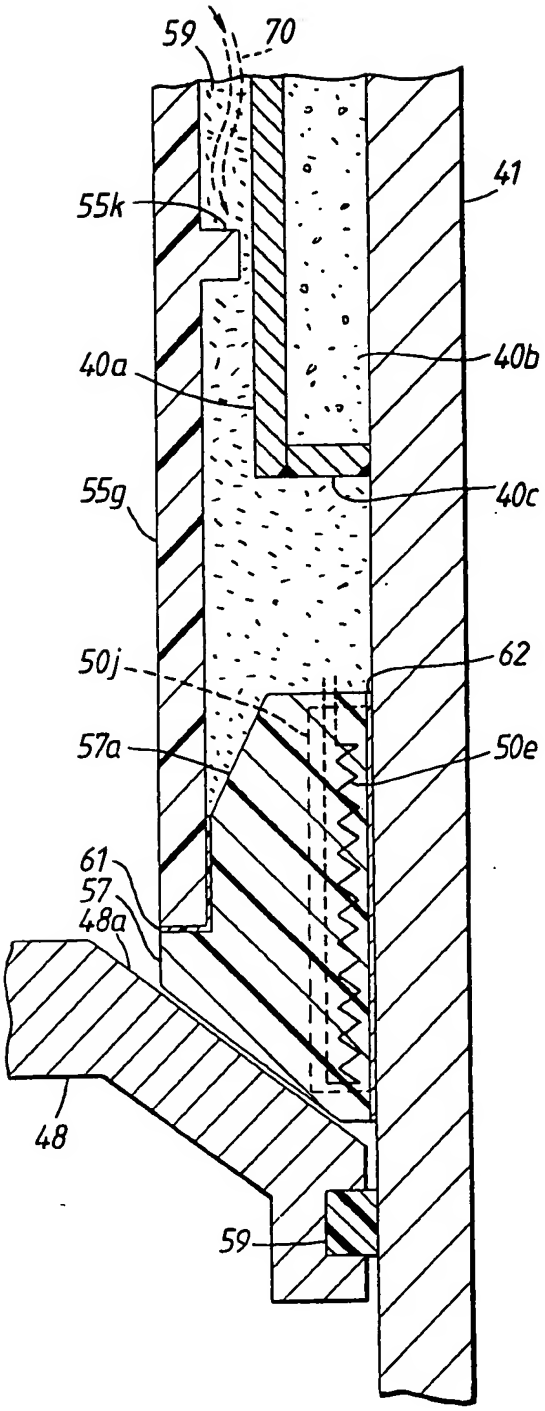
59
70
41
55k
40a
40b
55g
40c
50j
62
57a
50e
61
57
48a
48
59

FIG. 4.

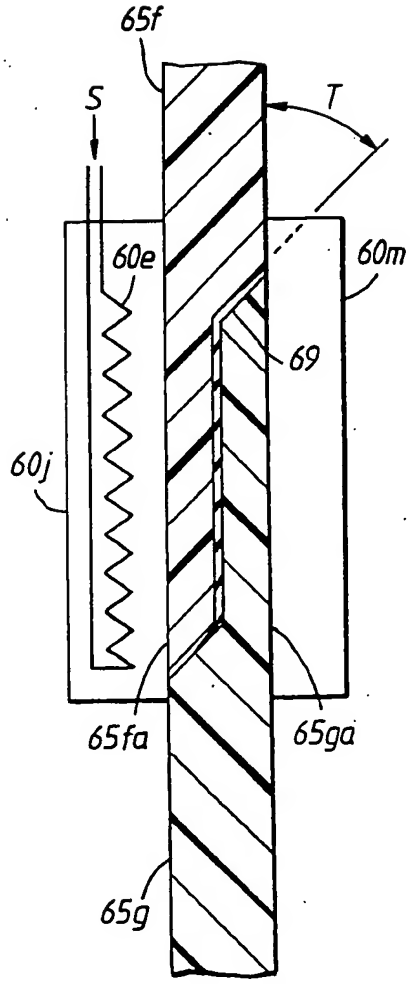
65f
S
T
60e
60m
69
60j
65fa
65ga
65g

FIG. 5.

SPECIFICATION

Method for applying a protective coating to an elongate structural element.

Coating of structural parts, for example steel parts, with rubber and various plastic materials in order to protect these parts against for example corrosion and mechanical injury, is previously known. This invention relates to a method for applying a protective coating to an elongate structural element of steel under such difficult conditions where that or those portions of the element to be coated, are not accessible directly for the workers who shall do the coating.

There may be contemplated many different situations in which a portion of such an elongate structural element is inaccessible to workers, for example because of space restrictions or as a result of safety hazards, such as gas risk or radioactive radiation or the like. A primary and concrete field of use with which the invention is concerned, is for corrosion protective coatings on risers on offshore oil rigs, in which a particularly critical zone with respect to corrosion and damage, is that portion of the riser which is located at the water surface. The so-called splash zone there constitutes a problem zone which requires specific precautions for effective maintenance, in order that inter alia the safety conditions do not become critical.

At such risers which on a production platform convey oil and/or gas up from below, there will as a rule be a problem to obtain sufficient room around the riser for necessary maintenance operations, in particular for applying a new corrosion protective coating in the splash zone. A possible solution would be to replace the whole riser or a substantial part thereof, but such a work involves very significant expenses. Serious efforts are therefore made in an attempt to find solutions which may make possible corrections and coating of such risers where they are installed and extended up in the platforms.

In such coating which is of interest here, it is absolutely necessary to keep the surface portions concerned completely dry during the work, which makes it necessary when treating the above risers in the splash zone, to provide for a dry room around the riser from a suitable level above the water surface to the necessary depth. This may be established by means of a box or a chamber according to the cofferdam principle. In the specific use for coating of risers and the like, the invention necessitates the use of such a box or cofferdam for closing-off the relevant zone of the riser against the surrounding mass of water.

As already indicated above, however, this invention has more general aspects and thus takes as a basis the situation where a protective coating shall be applie structural element of steel and with large dimensions compared to the reach of a worker using common hand-tools, whereby a portion of the length of the element is inaccessible for workers, and whereby the coating shall comprise a sealed sheath of rubber or plastic material in sheet form.

What is novel and specific to the method according to the invention consists in a combination of a number of steps as follows:

—that the inaccessible length portion as a whole or possibly piecemeal, is sand-blasted by using a remotely controlled manipulator arm being controlled from an accessible workplace just outside the inaccessible length portion,

—that at least a temporary protective layer is applied to the sand-blasted steel surface by means of the manipulator arm,

—that a split or divided and prefabricated ring seal is applied around the element at the workplace and is moved to the remote end of the length portion as seen from the workplace,

—that the ring seal is joined and tightly attached around the element at said remote end of the sandblasted surface,

—that possibly additional sand-blasting, respectively applying of temporary protective layer is effected,

—that a first sheath section of sheet material is placed around the element at the workplace and two opposite edges of the sheath section are joined so that the latter extends continuously around the whole periphery of the element and with a small space with respect to the element,

—that the first and joined sheath section is displaced by a length step from the workplace in the direction towards the remote end,

—that a second sheath section of the same material is placed around the element and joined as stated above and moreover joined around the periphery to the adjacent edge of the first sheath section,

—that the joined first and second sheath sections are displaced by a length step from the workplace in said direction,

—that a third, possibly a fourth and additional sheath sections are successively placed around the element, joined and displaced by length steps as stated above with respect to the first and the second sheath sections, until the desired length of the coating is obtained,

—that the joined sheath sections are displaced sufficiently long in order that the most remote edge of the first sheath section will get into cooperative engagement with a surface intended therefor on the ring seal,

—that said most remote edge of the first sheath section is joined to the ring seal,

—that all said joints are made fluid tight so as to form a sealed sheath,

—that a filler is introduced from the workspace between the elongate

element and the closed sheath so that all cavities and interstices are completely filled, and

—that the close end of the sheath is tightly sealed, preferably with the same material as in the sheath, by direct manual work at the workplace using suitable hand-tools and utensils.

When referring to an elongate structural element here, this comprises the most different types of structural elements having such dimensions, in particular in the longitudinal direction, that the coating may extend over several meters away from the accessible workplace at which workers may stay during the operation. The structural elements may have a round, rectangular, square or other cross-sectional shape and may possibly be provided with an internal cavity, for example being a conduit or a riser as mentioned above. Moreover, the cross-section may be constant along the length of the element, but the invention is not limited to elements having a completely constant cross-section. In particular when the element has only a slowly increasing cross-section in the direction away from the workplace into the inaccessible length portion, it may still be possible to utilize the invention.

The invention shall be explained more closely below with reference to the drawings, in which:

FIG. 1 purely schematically shows the fundamental situation which constitutes a basis for the method according to the invention,

FIG. 2 shows an example of a finished coating on a vertical tube shaped structural element, such as a riser, produced by means of the method according to the invention,

FIG. 3 shows an arrangement which may be used when performing the method according to the invention, for applying a coating as shown in FIG. 2, the initial steps of the operation being illustrated in a much simplified manner,

FIG. 4 shows more in detail and at a larger scale, certain important features at the lowermost part of the arrangement in FIG. 3, and

FIG. 5 shows a cross-section through a joint between sheet or sheath sections which are incorporated into the coating.

In FIG. 1 it is illustrated quite generally what is the fundamental situation which the present invention takes as a basis or starting-point. There is shown an elongate structural element 1 which may have any orientation, here extending at a moderate slope upwardly towards the right in the drawing. A portion 2 of this element shall be coated with a rubber or plastic material for protection against corrosion or other undesired influence. With a dividing line 3 there is indicated a boundary between an inaccessible area B, in which the interesting portion 2 is located, and an accessible area A in which it is possible and permitted for workers to operate. As mentioned the area or portion B may be inaccessible for example because of space restrictions, safety conditions or the like. With various types of tools, utensils and equipment being known per se, workers in the accessible area A may be able to perform operations within area B by extending tools, utensils and auxiliary equipment as well as components and materials to be incorporated into the coating, in the direction indicated by the arrow C along the element 1.

The invention shall be discussed more specifically below with reference to the subsequent figures of drawings, being directed to the particularly interesting case where the elongate structural element is a riser on an offshore oil rig or platform, and the interesting portion of the riser lies in the splash zone. It will be realized that solutions corresponding to or being analogous to those to be explained more closely below, more or less directly may be transferred or adapted to the general situation which is illustrated schematically in FIG. 1.

FIG. 2 shows a riser 11 in the region above and below the water surface which is indicated at W. A usual dimension of such a riser may be a diameter of about 1 m. The length portion of the riser in the splash zone for which protection is desired, may have a length of 8—10 m. In the example shown here it is assumed that there has been made an attempt earlier to make a corrosion protection at the portion concerned of the riser 11. This earlier protection consists of a steel plate 10a and a layer of concrete 10b cast between the plate 10a and the actual riser 11. It has been found that this form of protection is not sufficient in the long run. With time there arises a strong need for correcting or repairing earlier installations with or without such extra protection in the splash zone, and the present invention has for an object to solve inter alia this specific problem.

With a dot and dash line 13 near the top of FIG. 2 there is indicated a dividing line or boundary between an accessible area or a possible workplace at this level and thereabove, and the area below which will not be directly accessible to workers. This shall be discussed more closely below with reference to FIG. 3. First there will be included here a short discussion of an example of a completed coating prepared by means of the method according to the invention, without going into details. The coating consists of an outer sheath 15 composed of sheath pieces or sections designated by letters a—g being inserted downwards to the left of the structure. Between these sections there are indicated joints such as I, II, and so on. When using rubber, which is a very interesting material in this connection, the thickness of the plate or sheath 15 may for example be 15 mm. Many different and strict requirements are set forth

to the material in such a protective sheath, inter alia with respect to mechanical strength, including tensile strength and elongation as well as hardness, chemical resistance, including ozone resistance, and so on. With present-day technology it is completely possible to find suitable qualities or compositions of rubber which satisfy these requirements very well.

At the bottom the rubber sheath 15 is fastened by vulcanization to a ring seal 17 which in turn is tightly attached by vulcanization to the surface of the riser 11. Between the tube 11 or the protective plate 10a respectively, and the surrounding rubber sheath 15 there is introduced a filler 19. As a filler there may be contemplated a number of different materials which may be cast or injected into the space shown. The purpose is that all cavities and interstices shall be filled with filler so that there will be no possibility left for the collection of water or moisture which in turn may attack the surface of the tube 11. Suitable filler materials are polyurethane, for example polyurethane foam, rubber-containing compounds, epoxy compound such as tar epoxy and asphalt and possibly concrete. It is important that the filler employed has a good adhesion both to the tube surface and to the sheath surface. In this connection it is pointed out that the surface of the riser tube 11 which is made of steel, is sand-blasted and possibly provided with at least one temporary protective layer, such as a primer, which may contribute to an improved adhesion of the filler.

At the top the complete protective coating or sheath 15 with filler 19 may be sealed by means of methods known per se, for example by using suitably shaped rubber elements 22 and a covering plate member 21, attached by vulcanization to the tube 11 and to the upper edge portion of the sheath 15, respectively. This sealing may be carried out in a conventional manner because the workers here may have direct access from the possible workplace above or near the dividing line as indicated at 13.

With the composition or structure of the protective coating as generally described here, there is obtained not only an effective corrosion protection, but in addition thereto a certain degree of mechanical protection since the filler and the rubber sheath 15 together constitutes a form of fender having certain advantages in addition to the purely corrosion protective effect, which is of primary concern. As mentioned the protective coating which as a whole is designated with reference numeral 12 in FIG. 2, is built up by a number of sections or sheath pieces a—g which may for example have a height of about 1 m with the above mentioned dimensions of the riser 11. The height or length of the sheath 15 should then be about 7 m. Such a coating may of course be provided irrespe[illegible] not the riser 11 has already a conventional form of protection, for example with a concrete layer 10b within a steel plate 10a.

In connection with the specific field of use shown in FIG. 2 the method according to the invention is illustrated more closely by means of FIG. 3. Here there is shown a riser tube 31 without any other previous reinforcement for corrosion protection, but otherwise corresponding to the situation of FIG. 2. Thus, the water surface is indicated at W and the inaccessible portion is assumed to be delimited upwards at a level approximately as indicated by the line 13 in FIG. 2. Thus, there is provided a compartment or a chamber 30 of the cofferdam type, the surrounding vertical walls 37 of which are terminated on the top at a level corresponding to line 13 in FIG. 2. The compartment 30 has a bottom 38 with a sealing as indicated at 39 against the tube 31. By means of a pump (not shown) the water has been removed from the interior of the compartment 30 and water which possibly may leak into or enter the chamber because of rain or the like, will be continuously pumped out, for the purpose of keeping the compartment around the interesting length portion of the tube 31, as dry as possible. Particularly in order to dry the surface of tube 31 there may also be provided for ventilation, preferably with warm air, so that the desired drying effect is obtained. This is of particular importance in connection with sandblasting.

For performing various operations or works within the room which is defined by the compartment or chamber 30, there is purely schematically shown a robot or manipulator 33 comprising a control unit 34, an arm 35 which may be extended into and moved in the compartment, including movements around the tube 31, so that a tool or apparatus or the like as indicated at 36 at the lower end of the arm 35, may perform various operations or processes in connection with the coating to be effected. There is here the question of robot or manipulating methods being previously well known and therefore not requiring any more detailed description. Also a video camera may in a way known per se, be utilized during these operations. Based upon the above given dimensions of the riser tube 11 the walls 37 may be located at a distance of 25—30 cm from the surface of tube 31, whereas the total height of these walls may be 8—10 m. In practice this will result in the necessary closing-off of the portion concerned of the tube, even with commonly occuring waves on the water surface W.

In the illustration of FIG. 3 it is presumed that the initial steps of the method according to the invention have been already in part performed and are in part being effected. Thus, the inaccessible length portion to be coated has been sand-blasted as a whole or [illegible]l from the bottom, by means of

the manipulator arm 35. Moreover, at least one temporary protective layer, for example in the form of a primer, may have been applied to the sand-blasted portion of the steel surface, this also by means of the manipulator arm.

As shown there has been guided down a prefabricated split or divided ring seal 47 having been placed around the tube 31 at the top at the accessible workplace near the upper edge of the walls 37, and then displaced downwardly to a point adjacent the bottom 38. Here the ring seal has been joined so as to be tightly attached around the tube 31. This is discussed more in detail below with reference to FIG. 4.

A sheath section or piece 45g is shown in the upper portion arranged around the tube 31 and held in position by means of a holding device 32. There is further shown a sheath section 45f in the process of being laid around the tube 31 for the purpose of being joined along its two opposite short ends or edges 49a and 49b so that there will be obtained a continuous section similar to the section 45g. Thus, section 45g has also been formed from an originally rectangular sheath piece inserted in a similar way as the sheath piece 45f. The arrow on the latter indicates the direction of insertion laterally from the workplace at the top of the walls 37. Possibly at the same time as joining the edges 49a and 49b the lower edge or periphery 49c of sheath section 45f is joined to the upper periphery of the first sheath section 45g. When a rubber material is used, the joint is by vulcanization in a manner known per se, which is to be explained more closely in connection with FIG. 5.

Each time a new sheath piece is introduced and shaped into a section of the complete sheath, there must be effected a displacement movement downwards into the room which is delimited by walls 37, which is effected by giving the holding device 32 a stepwise downward and controlled movement adjusted according to the working rate in the shaping and joining of the individual sheath pieces. The size of these is so adapted that handling and joining may take place without any problems by scilled workers having the necessary tools and equipment located on a working platform (not shown) around the top of walls 37.

The successive joining and building-up of the complete sheath in this manner continues until the time when the lower periphery of the first sheath section 45g may be moved down into engagement against the ring seal 47 which is already in its position at the lower end of the length portion of tube 31 which is to be coated. This sheath section is then joined by vulcanization to the ring seal 37 as will be explained more closely below. When the sheath has been built-up to its final height and has been made fluid tight at all joints, the filler may be introduced, which is also effected from the workplace or platform at the top of walls 37. Depending upon which filler is used, the introduction thereof may take place in different ways, for example quite simply by pouring the same into the space between tube 31 and the sheath.

Finally, the upper end is tightly sealed as shown in FIG. 2 by means of conventional materials and techniques, made possible thereby that this part of the assembly is directly accessible for workers at the top of walls 37.

The previously mentioned sand-blasting may be carried out along the whole relevant length portion of tube 31 at once, or the sand-blasting may be effected piecemeal, in particular by first and separately to sand-blast the lowermost portion at which the ring seal 37 shall be mounted. The above mentioned length steps for moving down the sections of sheath pieces, for example the sheath sections 45g and 45f in FIG. 3, may correspond to the height of each sheath piece or each section, which involves the displacement of one such length step for each section, or the length steps may be different therefrom, with a correspondingly changed rate of displacement movement. This is a purely practical question which depends upon the space relationships and the dimensions of the sheath sections, with a possibility for the workers to adjust the displacement movement or rate according to the actual situation and the conditions otherwise. The holding device 32 is shown in cooperation with the lowermost or the first sheath section 45g, but it is obvious that this device has been shown only schematically for its fundamental function, since the holding or descending function may take place with cooperation between the holding device 32 and each of the sheath sections being joined together, and since the holding device may support or engage the sheath sections at several points distributed around the periphery of these pieces or sections. It is moreover obvious that the gravity will contribute to a high degree in causing the necessary displacement or movement downwards, so that the holding device or devices 32 may be of a comparatively simple design, without the necessity of any significant power requirement.

FIG. 4 shows an enlarged cross-section being approximately at a natural scale, of important details, in particular at the lower or remote end of the coating, including a special configuration at the bottom of the chamber described.

The riser wall 41 has here an earlier reinforcement or protection as mentioned above, in the form of a steel plate 40a and a concrete layer 40b. At the bottom this reinforcement is terminated by a steel ring 40c welded to the riser tube 41 and the protective plate 40a, respectively. As such a protection has

been found not to be good enough, it is necessary with corrections or a new protection, which is obtained by means of the method according to this invention.

The ring seal 57 is shown here with a specific cross-sectional shape aiming at a correct and accurate mounting and joining, respectively, to the riser tube 41 and the first or lowermost sheath section 55g. The downward surface of ring seal 57 has a substantially conical shape which is adapted to cooperate with a funnel shaped recess 48a radially innermost of the bottom 48 in the surrounding chamber. The sealing of the chamber bottom against the tube 41 is indicated at 59. The effect of these conical surfaces consists therein that the initially split or divided ring seal 57 is automatically guided to the correct position in engagement against the tube 41. By pressing downwardly on the upper side of the ring 7 there is simultaneously generated a radially inward pressure which in the first place brings the joint or joints in the divided ring seal against each other, and in the second place gives the necessary clamping force in the interface between the riser and the inner cylindrical surface on the ring seal. Since the ring seal in the common way has been cured beforehand there is temporarily as known per se, provided a layer or a sheet 62 of uncured rubber on the inner cylindrical surface of the ring seal. The manipulation or pressing action which is necessary in order to bring the ring seal 57 into its proper position as described here, may be provided for by suitable tools or equipment, possibly by means of the manipulator arm as described in connection with FIG. 3.

When, as described here, the coating is built-up from sheets and other parts of rubber, it is necessary to have a source of heat for the joining by hot-curing, as known per se. Such heating may involve problems at the rather inaccessible point where the ring seal 57 shall be fixed at the bottom of the surrounding chamber. A specific solution of this problem is shown here in the form of an electrical heater element 50e which is incorporated in the ring seal 57 itself. The heater element 50e is shown quite schematically and is so located that the heat generated will to a substantial degree be useful for the curing to be effected in the sheet 62. The heater element 50e of course extends around the whole periphery in order to be able to heat the whole engagement surface between the riser 41 and the ring seal 57. On the upper side of the ring seal there are indicated two short protruding electrical conductors which have been used for the current supply to the heater element 50e.

The heater element 50e may be directly moulded into the ring seal 57 or it may be formed as a separate annular element having a rectangular cross-section

seal 57 may have a complementary recess as indicated with the dash line 50j. In this way the heater element will be a separate member mounted in this recess 50j and fixed by vulcanization therein during the above curing in order to obtain attachment to the riser tube 41. In both embodiments the heater element 50e will remain incorporated into the finished sheath or corrosion protective coating with which the riser tube 41 is provided.

Also at the top the ring seal 57 has a conical guide surface as shown at 57a. This guide surface makes it easier to get the lower edge of the sheath section 55g in position engaging a shoulder formed for this purpose at the outer periphery of ring seal 57. For joining by vulcanization at this place there is shown a sheet 61 of unvulcanized rubber which beforehand preferably may be temporarily mounted on the ring seal 57 during down-movement and attachment thereof to the riser 41. Necessary heat supply for the curing of this joint may take place from the encased heater element 50e or by means of a separate heater device, i.e. a so-called heat iron in for example the form of an annulus which is mounted around the whole joint region for heating the sheet 61. According to common practice such a heat iron will be pressed against the parts to be joined, so that the riser tube 41 itself here will constitute a form of die block which makes possible this pressing or clamping effect.

Inside the sheath section 55g there is shown a projection 55k which serves to maintain a space between the sheath section and the structural parts inside it, i.e. either the riser tube itself or a reinforcement plate 40a thereon. There are applied a number of such projections distributed over the interior surface of all sheath sections, so that the assembled sheath everywhere will lie with a certain spacing with respect to the structure inside it. Thus, everywhere a passage is secured for the filler which is to be introduced at a later step of the operation.

Similar to the ring seal 57 the sheath section 55g and the other sheath sections may suitably be manufactured of rubber by form pressing as known per se. Such prefabricated parts will be manufactured in such case at a rubber factory by means of known technology. It is obvious, however, that there exist plastic materials which may be used quite in analogy to the rubber material described, for the purpose stated here. Moreover, it is clear that the joint between the parts may be effected in other ways than by hot curing. As known, there also exist methods for cold curing, i.e. vulcanization at a low temperature whereby specific precautions for heat supply are not needed. A disadvantage of cold curing is that it requires a comparatively long time. Furthermore there are various types of adhe-

ıay be used for the joints, both

when the material is rubber and when it is a plastic material. As an alternative to electrical resistance heating as discussed above, there may be employed other types of heating, for example electrical induction heat for possibly required heating.

When the complete sheath structure is assembled and all joints are finished, both with respect to sealing and mechanical strength, the introduction of filler 59 may be effected. As mentioned this may be performed quite simply by pouring this filler from the top of the structure, or as indicated in FIG. 4, by means of a tube or a hose 70. This hose is extended down into the space under control from the work platform at the top of the structure, and may be coupled to a pump or another aggregate for supplying the filler concerned, for example expandable polyethylene. Initially the output end of the hose 70 may be placed near the bottom of the structure and may then be pulled gradually upwards as the filling is effected. During this injection of filler it must be carefully checked that all cavities and interstices in the space between the sheath and the riser tube are actually filled with the filler material.

FIG. 5 shows at an enlarged scale a cross-section through a joint between the edges of two sheath sections 65f and 65g. This may for example be a joint as indicated at I between the sheath pieces or sections a and b at the top of the sheath 15 in FIG. 2. However, the form and process of joining as illustrated in FIG. 5 may also be used for connecting two short sides of a rectangular sheath piece, so that this will form a continuous cover around the riser, such as the joint between the edges 49a and 49b of the sheath piece 45f shown in FIG. 3.

The two edge portions as shown in FIG. 5, are provided with a step to the half of the plate thickness so that these portions may be placed with mutual overlap and an intermediate sheet 69 of uncured rubber. The stepped portions on both plate parts are terminated by sloping surfaces which may preferably form an angle T of about 45° to the plane of the sheath pieces. With such a shape the compression of the surfaces during curing will be favourable and apt to secure a flawless joint.

The joints to which FIG. 5 is related, are made according to FIG. 3 under more or less direct control from the accessible workplace on the platform at the top of walls 37, which also makes it possible to use more or less conventional methods and equipment for the joining operation. This comprises inter alia the use of heating devices or so-called curing irons being adapted to the joints concerned. Thus, FIG. 5 shows a curing iron 60j having an electrical heater element 60e the current supply to which is provided for as indicated at S through wires from the outside. On the opposite side of the joint there is placed in the usual way a die or counterblock 60m which during the curing makes it possible to exercise a certain compressive force on the parts to be joined. More specifically the curing iron 60j covers the overlap portion 65fa which is stepped-down from sheath piece 65f to about half the thickness thereof, whereas the die block 60m in a similar manner covers the overlap portion 65ga belonging to sheath piece 65g. As appears from the drawing it is practical that the curing iron and the die extend somewhat beyond the width of the actual joint region, as represented by the vulcanization sheet 69.

Heating devices or curing irons as schematically shown in FIG. 5, may be designed for curing longer or shorter continuous lengths of joints in the protective sheath to be produced. Thus, for example one curing iron in an assembled condition may be used for simultaneous curing of a complete periphery between two sheath pieces or sections located above each other, and the joints between adjacent edges on the upper one of the two sheath pieces.

As apparent from the above description, it is possible at several steps in the method according to the invention, to make modifications, including the choice of material, the joining method, the extent of the above length steps on displacement along the elongate element, respectively the piecemeal preparation, such as the sand-blasting. Many of such possible modifications may be contemplated within the scope of the fundamental method as stated and being useful in the general situation schematically shown in FIG. 1. When more particularly it is the question of coating riser tubes on oil rigs with an arrangement as shown in FIG. 3, there may additionally be mentioned possible modifications of the method as follows: In order to keep the inner compartment dry during bad weather, for example rain, there may be provided a cover on the top of the walls 37. Like the bottom 38 such a cover should be mounted with a relatively tight seal against the riser 31. Once there has been provided in this way a completely enclosed compartment around that portion of the riser which is to be treated, it would further be possible to take advantage of this room for introducing various processing media, possibly at an increased pressure, for example hot air or vapour for necessary heating for curing or another type of joining. In such case there will be established a form of autoclave curing which is well known within the rubber technology. The function of the holding device 32 in FIG. 3 may alternatively be carried out by means of the arm 35 provided with suitable devices at its lower end.

Finally it shall be pointed out that the provision of and the use of a rubber element having a heater element incorporated therein,

as discussed in connection with the ring seal 57 in FIG. 4, will have general possibilities of use within other fields when a rubber element shall be attached by vulcanization to another element, either of rubber or a different material, such as steel.

CLAIMS

1. Method for applying a protective coating to an elongate structural element (1, 11, 31, 41) of steel, for example a riser on offshore oil rigs, and with large dimensions compared to the reach of a worker using common hand tools, where a portion (B) of the length of the element is inaccessible for workers, and whereby the coating shall comprise a sealed sheath of rubber or plastic material in sheet form, characterized therein

—that the inaccessible length portion (B) as a whole or possibly piecemeal, is sand-blasted by using a remotely controlled manipulator arm (34, 35, 36) being controlled from an accessible workplace (A) just outside the inaccessible length portion,

—that at least a temporary protective layer is applied to the sand-blasted steel surface by means of the manipulator arm,

—that a split or divided and prefabricated ring seal (47) is applied around the element (31) at the workplace and is moved to the remote end of the length portion as seen from the workplace,

—that the ring seal (47) is joined and tightly attached around the element (31) at said remote end of the sand-blasted surface,

—that possibly additional sand-blasting, respectively applying of temporary protective layer is effected,

—that a first sheath section (45g) of sheet material is placed around the element (31) at the workplace and two opposite edges of the sheath section are joined so that the latter extends continuously around the whole periphery of the element and with a small space with respect to the element,

—that the first and joined sheath section (45g) is displaced by a length step from the workplace in the direction towards the remote end,

—that a second sheath section (45f) of the same material is placed around the element (31) and joined as stated above and moreover joined around the periphery to the adjacent edge of the first sheath section (45g),

—that the joined first and second sheath sections are displaced by a length step from the workplace in said direction,

—that a third, possibly a fourth and additional sheath sections are successively placed around the element, joined and displaced by length steps as stated above with respect to the first and the second sheath sections, until the desired length of the coating is obtained,

—that the joined sheath sections are displaced sufficiently long in remote edge of the first sheath section (45g) will get into cooperative engagement with a surface intended therefor on the ring seal (47),

—that said most remote edge of the first sheath section (45g) is joined to the ring seal (47),

—that all said joints are made fluid tight so as to form a sealed sheath,

—that a filler (19, 59) is introduced from the workplace into the space between the elongate element (11, 41) and the closed sheath (15, 55g) so that all cavities and interstices are completely filled, and

—that the close end of the sheath is tightly sealed (21, 22), preferably with the same material as in the sheath (15), by direct manual work at the workplace using suitable hand tools and utensils.

2. Method according to claim 1, whereby the elongate element is a substantially vertical riser (11, 31, 41) which is surrounded by a chamber (30) the bottom (38) of which is mounted with a tight engagement (39) around the periphery of the riser somewhat below said remote end and the walls (37) of which extend approximately to the intended upper termination of the coating to be applied, water in the chamber (30) being removed by means of a pump and the chamber possibly comprising means for enforced drying of the surfaces to be coated, characterized in that said displacement of the ring seal (37) and the sheath sections (45g, 45f,and so on) from the workplace at the top of the chamber (30) takes place by means of gravity and under guidance of a holding device (32) which is extended from the workplace to cooperate with at least the first sheath section (45g).

3. Method according to claim 1 or 2, characterized in that the temporary protective layer or layers comprise a primer being adapted to give a good adhesion for the filler.

4. Method according to claim 2 or 3, characterized in that adjacent and around the element (41) at the bottom of the chamber there is provided a funnel shaped recess (48a) and that the down-facing surface of the ring seal (57) has a correspondingly conical shape so that the ring seal upon downward pressure is also pressed radially towards the element (41).

5. Method according to any one of claims 1—4, whereby a heating action is effected for said attachment of the ring seal (57), characterized in that there is incorporated into the ring seal (57) itself a preferably electrical heater element (50e).

6. Method according to any one of claims 1—5, characterized in that there are employed sheath sections (65f, 65g) which along the edges to be joined to other sheath sections, are formed with complementary overlap portions (65fa, 65ga) being stepped down to e thickness of the sheath sec-

tions, and that the stepdown comprises inclined surfaces at an angle (T) of preferably about 45° with respect to the plane of the sheath sections (65f, 65g).

7. Method according to any one of claims 1—6, characterized in that on the inside the sheath sections (55g) are provided with projections (55k) in order to secure said space for the filler (59).

8. Method according to any one of claims 1—7, characterized in that polyurethane is employed as filler (19, 59).

9. Method according to any one of claims 1—8, characterized in that there is employed an expandable filler (19, 59), such as polyurethane foam.

10. Method according to any one of claims 1—9, characterized in that there is employed a filler (19, 59) which provides a good adhesion both to the elongate element (11, 41) and to the sheet material in the sheath (15 55g).

11. Method according to any one of claims 1—10, characterized in that the filler (19, 59) is injected into the space by means of a hose or a tube (70) being inserted from the accessible workplace.

12. Protective coating for elongate structural elements (11) of steel, for example risers on offshore oil rigs, comprising a sheet formed sheath material of rubber or a plastic material, which extends continuously around the periphery of the structural element, characterized in that between the sheath (15) of rubber or plastic material and the steel surface there is introduced a filler (19) which completely fills all cavities and interstices in the space and which has a good adhesion to both the sheath material and to the steel surface, the steel surface being possibly provided with a temporary protective layer or a primer.

13. Rubber element being adapted for vulcanization to another element by heat curing, being possibly also consisting of rubber, characterized in that it is provided with a preferably electrical heater element for generating heat for the curing, said heater element remaining an integral part of the rubber element after completed curing.

Printed in the United Kingdom for
Her Majesty's Stationery Office, Dd 8818935, 1985, 4235.
Published at The Patent Office, 25 Southampton Buildings,
London, WC2A 1AY, from which copies may be obtained.